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DEVELOPING TRADEOFF CRITERIA FOR USE IN REVIEWING MAINTENANCE TRAINER

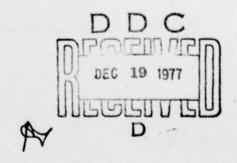
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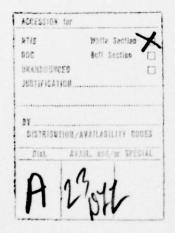
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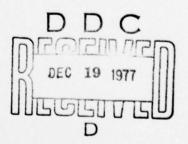
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INTRODUCTION

This report documents Phase I of this AIRTASK and presents a plan for Phase II. During Phase I, discussions were held with NAMTRAGRU H.Q., COMNAVAIRPAC, and COMASWWINGPAC Staffs, NAMTRADET 1036 and VS-41 FRAMP personnel. Each of these provided useful suggestions and meaningful insights which helped guide the conduct of Phase I and the development of plans for Phase II. Specifically the discussants provided valuable guidance on the selection of aircraft systems for study.

The following items were accomplished during Phase I:

- Task Identification Matrices (TIMs) were developed for organizational maintenance of the following S3A subsystems:
 - (a) Automated Flight Control System,
 - (b) Environmental Control System,
 - (c) Fuel and Inflight Refueling System, and
 - (d) Auxiliary Power Unit.
- The capabilities of existing maintenance trainers for the above systems and their use in teaching were documented.
- 3. The FRAMP curriculum was reviewed.
- 4. The procedures used by Lockheed for the development of existing courses were reviewed.
- 5. Detailed observations were made of technicians performing maintenance.
- 6. A complete library of S3A organizational maintenance manuals was assembled and those dealing with the selected systems were reviewed.
- 7. A Phase II plan was developed and is presented in appendix B.

The TIMs are included in appendix A. These tasks will be provided as a baseline for the Phase II contractor to use in the development of trainer/media specifications.

CURRENT NAMITRADET/FRAMP TRAINING AND TRAINERS

Automatic Flight Control System Training - Most of the two weeks spent in the AFCS training involves using handouts and technical manuals, primarily schematics, to review interfaces between the AFCS and other aircraft systems. The instructors feel that the trainees need to know more about interfaces to be able to identify problems caused by other systems, but reflected through the AFCS. The AFCS trainer shows what the components look like, but not how the components are installed in the aircraft. Most of the components indicate failure symptoms through the flight control system, so there is a "silhouette"

of the aircraft on a pedestal attached to the trainer with miniature control surfaces that move in response to control inputs. The trainer has a partial cockpit mockup that permits trainees to "fly" the silhouette. Both trainees and instructors expressed the feeling that, although the trainer is fun to fly, it is of little value as it relates to the job of maintaining the AFCS. The instructors wish that the AFCS trainer were connected to the Flight Control System trainer, so that the trainees could see the real flight controls move instead of just the silhouette, but they agreed that even this additional level of sophistication in the trainer would not substantially affect the learning of troubleshooting and repair. Most of the flight line level troubleshooting performed on the AFCS is achieved through a built-in test panel in the pilot's instrument panel. For the past 1-1/2 years, all of the aircraft systems have had this automatic built-in test equipment, but the "autobite" modification was just being installed in the trainer during our visit. This means that for the last 1-1/2 years, the trainer has been incapable of supporting practice of the primary automated troubleshooting task that forms the bulk of the organizational level troubleshooters' activities.

While more detailed task analysis will be required to arrive at a firm conclusion, it seems reasonable to assume that a trainer using actual aircraft components can be replaced using less costly media and/or a simulation based trainer. Avionics systems such as the S3A AFCS with effective BIT and good maintenance manuals would seem to be likely candidates for cost savings in maintenance training hardware.

Fuel System Training - At the NAMTRADET, about 2-1/2 days are spent on Fuel System, of which about 5 hours are spent standing around the Fuel System trainer. The instructor indicated that the trainer is used exclusively for "show and tell." There is no hands-on practice with any of its components, since it would leak a lot and require excessive maintenance if it were manipulated in this way. The trainer is the only training equipment in use for Fuel System training.

The trainer has a capability for insertion of several faults through the instructor's panel, but the faults do not produce the same symptom in the trainer that they do in the aircraft, so none of the instructors use this feature. The trainer is a scale model using mostly actual components, but it also uses some trainer-peculiar components. The instructor said that principles of operation and the traditional kind of troubleshooting discussion are supported mostly by handouts and technical publications, and that little or no time is devoted to discussion of removal, installation, or other maintenance procedures. The instructor expressed admiration of the ECS Environmental Control System trainer, and wished that he had a similar means of depicting what goes on in the Fuel System to aid in teaching principles of operation and troubleshooting. Since the trainer conceals most of the things that it does, other than filling up various cells (which can be watched through windows in the cells) it doesn't really help much in describing how the system operates.

The Fuel System trainer seems to be a prime example of a traditional approach, via existing Military Standards, which is inappropriate to the teaching requirement. More detailed task analysis in Phase II should allow the determination of more appropriate training support requirements. It seems clear at this point,

¹This is a hardwired panel which is similar in appearance to the EC II LP.

however, that any future procurement of similar fuel system trainers should be scrutinized to insure there is a specific need to support identified instructional requirements which cannot be met with less costly approaches.

Auxiliary Power Unit - Maintenance of the APU at organizational level is extremely limited. The service in the aircraft consists of tightening connections if leaks are observed, refilling the oil tank, and removing and installing the entire APU. If an APU is removed, it is taken back to the shop. If it needs anything other than cleaning of filters, it is generally sent back to the intermediate-level shop. Only hands-on practice associated with the APU is removal and installation the aircraft, using a trainer that consists of an actual APU and a mockup of the compartment in which the APU is installed in the aircraft. Two-man teams can practice disconnecting the lines, sliding the APU out on its tracks, and removing it from the trainer. Handouts and technical manuals are used for limited discussions of principles of operation and troubleshooting.

Trainer support for APU maintenance seems adequate. Only limited savings seem promised through a more detailed analysis of APU maintenance tasks. It is recommended that, if adequate funding is available, the "O" level power plant maintenance tasks be analyzed, since it seems that requirements for hands-on practice might be achieved in the FRAMP with NAMTRADET theory training supported by media other than trainers.

Environmental Control System - Existing technical publications for the Environmental Control System assume the use at organizational level of a test set that no one actually uses. It was discovered that the tester did not test a number of things that it was supposed to, and it was nearly impossible to use because of space limitations in the aircraft. As a result, almost all of the troubleshooting performed at the organizational level is "shot-gunning," (without the use of the tester) a term offered by the people interviewed in the shop. Rather than expand the NAMTRADET course to try to give troubleshooters additional background to make up for the failure of the tester, the course was cut almost in half when they found that the tester was not usable at the organizational level. The students were given handouts consisting of workbooks with questions.

Theory of operation, operational checks, and troubleshooting (deriving symptoms from known component failures) were all taught using a large training device called "the panel." This device is a large graphic depiction of the system schematic, with back-lighted data flow lines and little rotating valves that can be used to show sequences of operation. The panel responds like the system to instructor inputs on a mockup of the flight cruise controls for the ECS. The instructors are extremely fond of and complimentary to the panel, but several of the people in the shop volunteered that they felt they hadn't learned much in the course that turned out to be of value on the job.

There is an additional ECS trainer that is used for hands-on practice of certain remove-and-install tasks for the ECS. This trainer consists of a mockup of the ECS compartment in the aircraft with a number of ECS components installed. The mockup includes fuselage formers and stringers, but no skin. Two-man teams practice several remove-and-install tasks, but for some of the more difficult operations one of the team members is occasionally permitted to stand outside the trainer and assist by reaching through the aircraft's skin, a condition that is

physically impossible in the real world. Nevertheless, a number of transferable skills are probably learned during practice with this device.

The instructor could recall only one ECS system modification that had to be installed in both of the training devices, and he indicated that this was done without much difficulty, requiring approximately one day to modify both trainers. The panel accommodates minor changes in data flow fairly easily.

It is expected that the detailed analysis of ECS maintenance tasks will yield specifications for a maintenance trainer which will use a great deal of simulation and allow the practice of troubleshooting. Additionally, this trainer should serve as an evaluation tool for the development of revised maintenance procedures to reduce the current reliance on "shot-gun" or trial-and-error troubleshooting.

Troubleshooting - Some time was spent talking with instructors about the distinction between troubleshooting as it is presently taught and troubleshooting as an activity that has to be performed on the job. All of the NAMTRADET instructors take essentially the same approach: they teach the system thoroughly, then talk their way through the system one component at a time, failing each component and showing how to figure out what the symptom of that component failure would be. This writer believes that troubleshooting, as an activity performed on the job, is a different activity that involves different mental processes: a symptom, that could be caused by any of a number of different failures, is brought to the man's attention and he must apply some process, hopefully a logical one, to isolate the cause of the symptom. Trainers incorporating simulation technology provide opportunities to teach troubleshooting viewed this way.

Review of Existing Task, Skill, Knowledge (TSK) Data - The TSK data from which the original S3A NAMTRADET courses were developed seems to be comprehensive and thorough. This was due in large measure to the assignment of four of the NAMTRADET Chief Petty Officers to Lockheed for several months. They instructed the Lockheed course developers in the use of NAMTRAGRU 1540.B and reviewed the products. Unfortunately, increasing pressure has been put upon the NAMTRADET to reduce course length. In revising courses to reduce training time, the course objectives, so carefully developed, have been revised into less specific, theory-oriented statements. For those systems studied in Phase II, task and training analyses will assist course managers in making courses job-specific and will provide supporting logic for course duration.

FRAMP PRACTICAL JOB TRAINING (PJT)

The FRAMP PJT curriculum was developed from the basic concept, expressed by CWO3 Larson, that they were training men to work in a maintenance department. To achieve this, a mini-maintenance office was set up with VIDS/MAF boards and a work assignment supervisor. Parts salvaged from a crashed S3A were used to create "bad" parts. A part, with known defects, was inserted in an aircraft assigned to the FRAMP and a gripe was entered on a VIDS/MAF NAVMACLANT TEST FORM 4790/41E. A total of 386 JOB PLANS, each with a different gripe, was created. On the face of it, this PJT looks like the most appropriate, well-thought-out training plan for maintainers. Because this PJT package is believed

to be unique in its completeness and in its approach, a thorough evaluation should be conducted. This evaluation is recommended as a follow-on to Phase II of this project. In many cases, an augmented FPAMP, using this PJT approach, can adequately handle all organizational level maintenance training.

Phase II of this effort has the following three goals:

- Develop a training system specification for training organizational level maintenance technicians for the S3A:
 - (a) Environmental Control System,
 - (b) Automatic Flight Control System, and
 - (c) Fuel Control System.
- Develop maintainer performance evaluation criteria to measure the effectiveness of training.
- Develop decision logic and criterion values for evaluating the adequacy of existing maintenance training units (MTUs).

The first goal will be accomplished under contract. The proposed statement of work is attached (appendix B). It is anticipated that this work can be completed 3 to 5 months after award of contract.

The second goal will be developed, using data developed during the accomplishment of the contract, by in-house effort. These performance criteria will be used as acceptance criteria for the MTUs. This task will be coordinated with the first goal and will be completed in 7 months.

The third goal would be accomplished as a joint in-house contractor effort with NAVAIR 413 designated personnel, NAVTRAGRU, and NTEC. The third goal will be pursued concurrent with the first and second goals, will be completed in draft form in 7 months, and will be validated and finalized after the procurement and evaluation of the specified maintenance trainers.

Phase II should be undertaken only if it is planned to buy the specified maintenance trainers and conduct an evaluation of their usefulness.

APPENDIX A

TASK IDENTIFICATION MATRIX (TIM) REPORT

prepared by

Applied Science Associates

APPENDIX A

TASK IDENTIFICATION MATRIX (TIM) REPORT

This report and its attachments document ASA's efforts in constructing and validating a Task Identification Matrix (TIM). The four subsystems selected for TIM development were the Auxiliary Power Unit, the Environmental Control System, the Automatic Flight Control System, and the Fuel and In-Flight Refueling System. Technical publications available to use here in Valencia were used to develop preliminary TIMs for all of the systems except the Automatic Flight Control System, for which we had insufficient documentation. The TIM for the AFCS was constructed at NAS, North Island.

Preliminary TIM Development - In constructing the TIM for each subsystem, we began by going through the Illustrated Parts Breakdown and identifying all functional components in the system that were authorized for any maintenance at the organizational level. We specifically excluded from the TIM such things as electrical and hydraulic connectors, hydraulic and pneumatic lines, and attaching hardware such as nuts, bolts, screws, washers, gaskets, brackets. Whenever it was unclear from the IPB or from associated work packages whether a particular hardware item was functional or not, the item was included as a line item in the TIM.

All line entries in the TIM qualified for remove-and-install tasks at the organizational level, at least, and were so noted. The maintenance and troubleshooting work packages for each of the systems were examined, and additional TIM cell entries were made to cover all tasks for which there were work packages or for which instructions were provided in work packages for other hardware items. When items were specifically mentioned at the terminal points of troubleshooting procedures, that fact was also noted in the TIM. Whenever work packages existed for more than one task for a given line item, references to the specific work packages were included in the "Notes" column in the TIM, and the cell entries were given subscripts corresponding to the notes. The letter "O" in a cell denotes the judgment that such a task is performed at the organizational level. A dash (-) in a cell indicates the judgment that no such task is performed at the organizational level. A "W" denotes both the existence of such a task and the presence of instructions for the task in a work package. As mentioned above, numerical subscripts to the "W" entries were used when a hardware item was covered by more than one work package. Page numbers and callout numbers from IPB or work packages were included with the line items in the TIM.

TIM Validation - Validation of the preliminary TIM was conducted at the North Island Naval Air Station in San Diego. The process followed in validating the TIM involved spending time with senior maintenance personnel in the shops responsible for maintenance of the systems with which we were concerned. We assembled the relevant technical publications and, as we proceeded through the TIM, we simultaneously tracked the IPB and the maintenance and troubleshooting work packages. Whenever questions arose that our experts couldn't answer, they would call in other people or we would resolve the question by examining the hardware involved, either in the shop or on the aircraft. For each line item in the TIM, every cell was investigated. In cases where we had inappropriately

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included or excluded a cell entry (according to the expert), the entries were corrected to conform to the expert's judgment.

Note that the construction of the TIM for the AFCS did not identify any troubleshooting tasks in connection with 0-level replaceable components. Trouble-shooting of the AFCS is accomplished at the whole system level using comprehensive BIT.

TABLE A-I - TIM FOR AUTOMATIC FLIGHT CONTROL SYSTEM

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TABLE A-I - TIM FOR AUTOMATIC FLIGHT CONTROL SYSTEM (continued)

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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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TABLE A-11 - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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	02/00 flage les Presuse	/	1	/	1	1	1	1	1	1	1	1		اجمرد	desco	
>	220	/	1	1	1	1	1	7	1	1	1	1	1			
	- X	*	1	1	1	1	1	7	1	1	7	1	7	0501.	27 20 400	
>	Le	01 10	1	1	1-5	1	1	1	/	1	2	1	1	3.5	00500	
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>	2500 Talm Float	17	8	/	1.	17	1	7	1	/	1/2	1	1	3.50	Orboden.	
>	2600 Halm F.	,	7	/	1	1	1	/	1	7	/	1	1			
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	02700 HANDLE MANDAL CONTROL	7	9	1	1	1	1	1	1	/	1	1	1			
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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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	37	1	1	1	1	1	1	1	34	1	1	7	19.00 F 20.65	
03000 Couches half Fuel		1	1	1	/	/	1	1	-	1	1	7		
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1 1031 00 Tales (Hok. File l.		1		/		1	1	1	1	1	1	1		
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1 103200 Hans Courted Roca		1	1	/	1	1	1	1	1	1	1	4		
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103300 areter Flan Victor	32	1	1	1	1	1	1	1	3	1	1		3 mereten	
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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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hir fresh		1	1	1	7	1	1	/	7	1	7	7	
1	/	/	-	1	1	1	1	1	2	6	7	7	
03600 These Check liv	14	1	1	3.	V	1	X	1	34	1	1	7	WP DOLCO
3600 Fitte	61	1	1	1	1	1	1	1	3.7	1	17	7	שבניים בש (
36000	30	/	4	37	1	1	1	1	3.4	1	1	7	0020000
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03600 Talve Prick, air	26	1	1	15.		1	1	1	3.5	7	1	1	Dr. P. 007.00
O Halue x		7	7	1	/		7	1	7	1	4	1	
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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTFM (continued)

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System Hardware Item Charles Sy		Ollavons	1		X	1	9	1	1	1	1	/	1		1	1	1	1	1	1	1	/
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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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TABLE A-II - TIM FOR FUEL AND IN-FLIGHT REFUELING SYSTEM (continued)

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TABLE A-III - TIM FOR AUXILIARY POWER UNIT

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TABLE A-III - TIM FOR AUXILIARY POWER UNIT (continued)

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GO 40216 Motor Riving Rivides	0 - 0
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00402241 Het der Paris Columb	6-11-11-11-11-11-11-11-11-11-11-11-11-11
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TABLE A-III - TIM FOR AUXILIARY POWER UNIT (continued)

TABLE A-III - TIM FOR AUXILIARY POWER UNIT (continued)

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TABLE A-III - TIM FOR AUXILIARY POWER UNIT (continued)

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TABLE A-III - TIM FOR AUXILIARY POWER UNIT (continued)

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System Hardware Item	Sullanote steam of st
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TABLE A-III - TIM FOR AUXILIARY POWER UNIT (continued)

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TABLE A-III - TIM FOR AUXILIARY POWER UNIT (continued)

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ary him I diester	1	1	X	1	X	1	1	7
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	111	-	7		7		7	
	7	-	7		7	1	1	
	7	1	Z		7		7	
	7	7	Z	-	7		7	
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			7		7	1	1	
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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

	Mainte	Maintenance Function
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Code System Hardware Item	2/6/dy	SSUL
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62000 Coupling Shut Mitte	4-11-11-11	
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1 6 2000 Tare Chick Remark	MANN	
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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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System Hardware Item O Chiefer of Green Range of Charles of Chiefer of Chief		10.	eus,	\	SULP	7	1	7	7	Z	9	1	9	7	1	2	7	7	1	1	7	1	/	/	1
System Hardware Item O Chiefer of Green Range of Charles of Chiefer of Chief		1	100	فالو	1	1	1	7	1	7	9	1	1	1	7	7	1	1	1	7	7	1	1	1	1
System Hady O Letter Direct O Chief the Chief O Chief the Control O Chief the Control O Chief the Control O Chief The Chief O Chief The Chi				\	3.68	3		7		P	00	Sa	18		3	7		X	7	27			12		1.1
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		Euroog	salqnoi	Code Code	June		7/	Ž	210		7	210	220	22006	7	2200 (4	230	N.	23006	2460	2500	77	Transition of the state of the		3100

TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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Code System Hardware Item	100	0.		/3	100	10,			,	1	essu		/	Notes	s
(rong	Sellor Sellor	ISNION	26114	182	040010	1000 See 10 See 1		Sildui	1 .gh	reday rough	TROOK	DINIES	/		
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Tropissues of Crievis	Jes !	1	1	1	1	/	/	1	3/	7	7	7	300	10800	
02500 Luted Busune Bissintal	John Street	/	1	1	1	N	7	/	3	1	7	7	10.	10110	
02500 Thermother, Industrie		1	7	7		7	7	4	7	7	7	7			
Control levision les	31	7	7	7	1	1	7	1	3/	7	7	7	400	10,800	
Thismed	19	1	1	1	1	Z	1	7	3	7	7		207	10305	
600 Cetust		1		7		/	1	1	7	/		7			
C	17	3	4	1	1	Z	8	1	2	7	7				
02600 Lew Honestick, St. Starter		7	7	7	1	1	1	4	4	7	7	7			
Lat fel Men			4			1	7		4		7	1			
- Hapsongh Unencer	36	7	4	1	X	4,	4	4	4	4	7	4	4	123==	Slect
02600 Minnortal Junterature		1	1			1	1								
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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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Code System Hardware Item	1	SeC es		1	100		Spieldi	100	/	"essul,	1		Notes
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03000 Luited from deflyited	40	1	1	7	1	1	7	Z	3/		1	3	0
3100	8	1	1	X	7	7	7	Z	3	7	7	127	50,800
3100 Coustes	12	1	1	1	7	1		1	9				
3	7	7	1	Z	/	-	1	Z	2	7	1		
3/00	13	1	1	1	/	6)	1	X	3	7	1	53	rejian
3/00 Centers, 6	8	1	1	7	/	-	7	7	2	7	7		
3/00/20	14	7	1	1		1	1	1	8	1	1		
03/00 Pulled. Alet Mit	16	1	1	X	7	4	1	Z	8	7	1		
310		1	1	Z	1	1	1	Z	7	1	1		
15.16 HOOK 115	17	7	1	N	1	3	1	N	3/	7	1	3	00100
Penderature		7		Z	7	1	4	Z	7	1	1		1
Jaken K	8	1	1	Z	1	7	N	7	3	7	1	53	20206
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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL COMPROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM

TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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TABLE A-IV - TIM FOR ENVIRONMENTAL CONTROL SYSTEM (continued)

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APPENDIX B
STATEMENT OF WORK

APPENDIX B

STATEMENT OF WORK

Develop, using Navy-provided task identification list (augmented by on-site contractor observations), a training system specification for organizational level maintenance training for the following systems of the S3A:

- 1. Environmental Control System.
- 2. Automatic Flight Control System.
- Fuel Control System.

The following sub-products must be developed and delivered, after approval:

- Skills and knowledges analysis identifying S&K required for performing described tasks:
 - (a) S&K in students repertoire and
 - (b) S&K to be acquired in training.
- 2. Specific Behavioral/Performance Objectives for training system graduates.
- Curriculum Outline.
- Media/Method selections.
- Functional and, where possible, material specifications for required MTUs.
- 6. Suggested entry level and completion tests to determine whether SBOs have been achieved.